

Problems in the Industrial Utilization of Tobacco¹

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SINCE a surplus of certain types of tobacco has developed in recent years, the Eastern Regional Research Laboratory of the United States Department of Agriculture has undertaken a program of research to find more extended industrial uses for tobacco. The program at present is directed principally toward the wider utilization of nicotine, because nicotine is already a commercial product and is one of the most unique constituents now known in this plant. Other constituents, however, show promise as industrial materials and are being investigated.

Nicotine has been an important product for many years. It is derived from tobacco factory by-products, such as stems, scraps, and other wastes and, to a lesser extent, from low-grade leaf of the fire-cured types. About a million pounds of the alkaloid have been recovered annually in this country. Until recently practically all of the nicotine was used in insecticides. Within the past year a considerable demand for it has developed for conversion into nicotinic acid. The main objectives at present, therefore, are more economical recovery of nicotine from tobacco, development of new and more efficient nicotine insecticides, and improvement in the oxidation of nicotine to nicotinic acid.

The principal methods which have been suggested for the recovery of nicotine are steam distillation, water extraction, and organic solvent extraction. Steam distillation is the method largely used in this country, although solvent methods appear to be employed in other countries. Aqueous extracts are often used as such without further isolation of the nicotine and usually near the site of extraction, since their low nicotine concentration prohibits commercial shipment. Steam distillation is cumbersome in that the concentration of nicotine vapor carried by the steam is around 4 per cent at best and, where a batch process is used, the average nicotine content of the distillate is usually less than 1 per cent. This necessitates the handling of a very large volume of distillate for each unit of nicotine. Vacuum distillation of tobacco has been tried with some success. The material is treated with lime and a minimum amount of water to liberate the free alkaloid. The

mixture is then subjected to distillation in a vacuum of less than 50 mm. Water comes over first, carrying less than 1 per cent of nicotine. When practically all of the water is removed and the temperature of the material is raised above the boiling point of nicotine at this pressure, nicotine with a relatively small content of water distills over. The resulting distillate, containing 80 per cent or more nicotine, could be purified readily and converted either to the pure alkaloid or to the 40 per cent nicotine sulfate of commerce. To the present this has been done only in a small way using inefficient equipment. The principle, however, seems to be sound, and equipment in which the industrial feasibility of the process can be determined is under construction.

Nonaqueous solvent extraction of nicotine may have possibilities of development. Unfortunately, there are considerable amounts of nonnicotine materials in tobacco which are soluble in the ordinary solvents. It is possible, however, that among the great variety of solvents available, some may be found which have a marked preference for nicotine and could meet other requirements, such as recoverability, cost, and freedom from hazards.

The case for aqueous extraction is further complicated by the still greater quantity of constituents soluble in water. An inexpensive and feasible precipitating agent which will remove the nicotine with a minimum of impurities may be found, however. The nicotine would then be recovered from the precipitate.

In the attempt to find new and more advantageous forms of nicotine for insecticides, several promising lines of work have opened up. What is believed to be a wholly new series of double salts or complexes containing nicotine has been developed. These salts consist of two basic and one acidic radical. An example is copper-nicotine-picrate. Over 40 different salts have so far been prepared involving copper, cobalt, cadmium, zinc, iron, nickel, picrate, benzoate, thiocyanate, cyanide, salicylate, and *o*-benzoyl benzoate. These salts are of constant composition, have high nicotine contents, are extremely insoluble in water, and are prepared readily as impalpable powders without grinding. Their insecticidal value is being tested. Those containing copper may have combined insecticidal and fungicidal value.

Rubber dust, either hard or soft, will absorb about 10 per cent of nicotine and still remain a dust. Above this concentration the mixture becomes gummy, and finally the rubber and nicotine become fluid. These dusts liberate nicotine rather slowly. They should, therefore, be effective insecticides over a period of several days, in contrast to dusts containing lime, where the nicotine is vaporized in a matter of hours. Similar combinations have been found between finely ground plastics of various sorts and nicotine, as well as other volatile insecticides such as ethylene dichloride. Again, it has been found possible to impregnate fine fibers, such as medullary wood fibers, with a dye and then form the nicotine salt of that dye in the fibers. These fibers adhere tenaciously to foliage and fruit.

On January 29, 1941, the Committee on Food and Nutrition of the National Research Council announced that wheat flour would be enriched by the addition of thiamin, nicotinic acid, and iron. This initiated an intensive search for adequate sources of nicotinic acid. In 1940 about 10,000 pounds of this acid had been manufactured for the treatment of pellagra. In addition, it is estimated that upwards of 200,000 pounds will be needed for flour fortification in 1942. Since nicotine has been the best known material for producing nicotinic acid, an unprecedented demand was created for this alkaloid. Quinoline and β -picoline are also possible raw materials but at that time, at least, were not available commercially. Therefore a race developed among these three starting materials. The Eastern Regional Research Laboratory started work immediately to improve the oxidation of nicotine to nicotinic acid.

Since a chemical source of oxygen such as nitric acid is costly for carrying on this reaction, air oxidation was attempted. Vapor-phase catalytic oxidation is being intensively studied. Some success has resulted, but it is premature to discuss the results in detail. Sulfuric acid oxidation in the presence of a catalyst works rather well, but here a chemical source of oxygen is again involved. It would be hazardous to predict from what source the nicotinic acid of the future will be obtained, but we feel that nicotine is still a logical source.

War in the Pacific may impose a still further demand on nicotine because of restricted importations of pyrethrum and

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A field of tobacco in Connecticut

derris for insecticide purposes. Since Africa may be able to supply these materials in sufficient quantity and nicotine can replace them for only certain purposes, it is difficult to predict just what the situation in this regard will be in the near future. The best estimate, however, seems to be that there will be a shortage of something like 300,000 pounds of nicotine this year, from at least three causes—its use in nicotinic acid manufacture, its use to replace derris and pyrethrum, and its increased agricultural use for greater food production. Attempts to make up this deficit are along three lines. First is the development of more effective means of using nicotine as an insecticide. Possibly some of the new compounds mentioned above will help; possibly activators or synergistic materials will be found. Second, a considerable poundage of low-grade leaf tobacco of certain types will be diverted from the ordinary leaf channels to nicotine manufacture. Such diversion has occurred during recent years, and it may be expanded during the present year. A third possible source of additional nicotine might be the growing of *Nicotiana rustica*, a species of tobacco which is not used for smoking in this country and contains about twice as much nicotine as ordinary tobacco. *Rustica* has been grown experimentally for a great many years in various parts of the country and constitutes a potential source of an appreciable amount of nicotine.

Other phases of tobacco chemistry are also being investigated at the Eastern Regional Research Laboratory. An attempt is being made to develop chemical standards for the grading of tobacco. Different grades are well established in the trade, and they are purchased for par-

ticular effects in blending for various tobacco products. A scientific basis, however, for defining these grades and explaining their particular qualities has never been established. Certain of the constituents of tobacco are known to exert a favorable influence on the value of the leaf, and others markedly detract from its worth. Some of these, however, have never been identified, and for others known to be present no satisfactory methods of quantitative estimation are available.

This project involves making a careful inventory of the constituents of tobacco, means for determining these constituents quantitatively, and application of this information to the grading of tobacco. This is naturally a long-time undertaking, and as yet it is too early to report results. It may be stated that definite progress has been made in the isolation and identification of certain of these constituents, particularly those that contribute to the aroma of the leaf.

As a result of these analyses, it is possible that some constituents of tobacco which may have industrial uses will come to light. It is known that tobacco contains appreciable quantities of citric and malic acids. In fact, earlier attempts have been made to recover these, and this laboratory is now studying methods for their recovery. Tobacco also contains unique essential oils, of some types in appreciable quantities. Pectin and the enzyme, pectase, are known to occur at least in the stems. A considerable quantity of resins, possibly suitable for coatings and plastics, is also present. The alkaloids, nornicotine and anabasine, occur with nicotine in certain types. Some attempts have been made to convert the residual fiber from nicotine recovery into fiber boards.

Tobacco, like any other crop, contains a variety of constituents, and every reasonable attempt will be made to evaluate the commercial possibilities of these constituents.

An attempt is being made to keep the research program on tobacco in tune with changing conditions. When this program was first started, the viewpoint was almost



Interior view of the pilot-plant wing of the Eastern Regional Research Laboratory. Findings of the chemical laboratories will be tested on a semiworks production basis in this wing. It is 65 feet wide, 258-feet in length, and has an overhead clearance of 45 feet in the center. Galleries 12 feet wide run the entire length of both sides.

wholly that of finding more extensive uses for a surplus commodity. It was felt that more extended uses for nicotine, for example, would consume more of the lower

grades of tobacco and maintain a better price for the other grades. The change in world conditions, however, has now altered this picture. Instead of wondering

how more nicotine could be used, we are now wondering where sufficient nicotine can be obtained.